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JACC Vol. 31, No. 2
February 1998:321–5

Cost Advantages of an Ad Hoc Angioplasty Strategy

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Objectives. **We sought to determine the cost advantage of a strategy of same-sitting diagnostic catheterization and percutaneous transluminal coronary angioplasty (PTCA) (ad hoc) in comparison with staged PTCA.**

Background. **It is widely assumed that an ad hoc strategy lowers costs by reducing the length of hospital stay (LOS). However, this assumption has not been examined in a contemporary data set.**

Methods. **We studied 395 patients undergoing PTCA during 6 consecutive months. Cost analysis was performed using standard cost-accounting methods and a mature cost-accounting system. Costs were examined within three clinical strata based on the indication for PTCA (stable angina, unstable angina and after myocardial infarction [MI]).**

Results. **For the entire patient cohort, there was no significant cost advantage of an ad hoc approach within any of the strata, although there was a nonsignificant trend toward an ad hoc approach in patients with stable angina. For patients treated with conventional balloon PTCA alone, the lack of a significant difference between ad hoc and staged strategies persisted. For patients who received stents, there was a significant cost advantage of an ad hoc approach in all three clinical strata. An important cost driver was the occurrence of complications. Differences in the rates of complications did not reach statistical significance between ad hoc and staged strategies, but even a small trend toward greater complications in patients who had the ad hoc strategy negated cost and LOS advantages. Our study had the power to detect significant cost differences of $1,300 for patients with stable angina, $2,100 for patients with unstable angina and $2,500 for post-MI patients. It is possible that we failed to detect smaller cost advantages as significant.**

Conclusions. **A cost savings with an ad hoc strategy of PTCA could not be consistently demonstrated. The cost advantage of an ad hoc approach may be most readily realized in clinical settings where the intrinsic risks are low (e.g., stable angina) or in which the device used carries a reduced risk of complications (e.g., stenting), because even a small increase in the complication rate will negate any financial advantage of an ad hoc approach.**

(J Am Coll Cardiol 1998;31:321–5)
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Percutaneous transluminal coronary angioplasty (PTCA) performed during the same sitting as diagnostic coronary angiography, so-called "ad hoc" PTCA, continues to generate controversy (1–4). The focus of the debate has been the safety of an ad hoc approach. The underlying assumption of pursuing an ad hoc strategy is that a more rapid and definitive resolution of the ischemic coronary problem will yield significant cost savings through shortened length of hospital stay (LOS) and improved patient convenience (5,6). The cost advantage of an ad hoc strategy has been evaluated only once previously, in a data set from a decade ago (4). Our aim was to examine the economics of ad hoc versus staged PTCA strategies in a contemporary data set.

Methods

Four hundred eighty-one patients underwent PTCA during 6 consecutive months (November 1995 through April 1996). For all PTCAs, clinical data gathered included an indication for the procedure (stable angina, unstable angina, after myocardial infarction [MI], acute MI, cardiogenic shock and "other"), age, gender, urgency of intervention (emergent, urgent, nonurgent), number of diseased vessels, number of lesions dilated, American College of Cardiology/American Heart Association lesion class (A, B1, B2 or C), ejection fraction and use of preprocedural intravenous heparin and nitroglycerin.

Our cost-accounting system is a mature one that systematically and comprehensively captures fixed and variable costs using accepted accounting methods. Each patient care activity has assigned to it a cost that has been derived by summing all identified variable costs as well as an allocated component of fixed costs. The allocation of institutional overhead to cost centers (such as the catheterization laboratory) is based on activity-based costing (i.e., costs of support services are allocated in proportion to the degree to which the clinical center uses the support service). Subsequent cost-center overhead and fixed costs are assigned to specific patient care activities by

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Manuscript received June 10, 1997; revised manuscript received October 29, 1997, accepted October 30, 1997.

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0735-1097/98/$19.00
PII S0735-1097(97)00512-3

Abbreviations and Acronyms

CABG = coronary artery bypass graft surgery
LOS = length of stay
MI = myocardial infarction
PTCA = percutaneous transluminal coronary angioplasty

a collaborative process involving the cost center manager and the cost-accounting staff. The cost accountants ensure that all costs are allocated comprehensively and in accordance with standard cost-accounting methods, whereas the managers assess that costs assigned to specific patient care activities represent a fair and equitable allocation. Cost information is linked to each patient charge code. An individual patient's cost summary is thus derived from his or her itemized hospital bill. For staged elective procedures, the costs of the preceding diagnostic catheterization and its associated hospital stay were added to the costs of the PTCA admission. We excluded staged procedures in which the diagnostic catheterization had been performed at another institution (n = 48), as we had no reliable means of accounting for costs incurred before admission to our hospital.

To have a meaningful comparison between staged and ad hoc procedures, we stratified patients according to the indication for PTCA. We have previously demonstrated that the clinical context within which PTCA is undertaken is an important determinant of overall costs (7). Failure to account for differences in case mix would bias the results. We therefore excluded patients who had primary PTCA for acute MI (n = 34) and cardiogenic shock (n = 3), as these procedures were, by definition, uniformly ad hoc. No comparable staged procedures exist. These two groups have considerably higher costs than other patient groups, and their inclusion would unfairly bias the results against the ad hoc group. Similarly, one patient in the ad hoc group was classified as having an "other" indication and was excluded from analysis. Thus we had three groups of patients: stable angina (n = 111), unstable angina (n = 179) and post-MI (n = 105).

We compared total costs of ad hoc versus staged PTCAs within each of the three clinical strata. To compare dichotomized variables we used chi-square analysis, and to compare continuous variables we used analysis of variance. Data are presented as the mean value ± SD.

Finally, to search for confounding variables, we performed several analyses. We examined if there were different rates of ad hoc procedures among the eight interventionalists; apparent economic differences in ad hoc versus staged strategies could have reflected the idiosyncratic practice characteristics of a given operator if that operator disproportionately performed his or her procedures either ad hoc or staged. Furthermore, we performed a multiple stepwise regression analysis to identify the baseline characteristics that were significant cost drivers. We then used the significant factors to adjust the case mix and repeated our analysis of ad hoc versus staged approaches.

Results

Patient characteristics are shown in Table 1. In general, the patients treated with ad hoc angioplasty and staged angioplasty were comparable with a few notable differences. Some patients in the ad hoc group, in both the unstable angina and post-MI

Table 1. Patient Characteristics

	Stable Angina			Unstable Angina			Post-MI		
	Ad Hoc (n = 42)	Staged (n = 69)	p Value	Ad Hoc (n = 95)	Staged (n = 84)	p Value	Ad Hoc (n = 67)	Staged (n = 38)	p Value
Age (yr)	61.4 ± 11.6	63.1 ± 11.0	NS	60.7 ± 12.6	61.1 ± 12.5	NS	57.9 ± 12.3	57.8 ± 10.5	NS
% male	76%	65%	NS	57%	69%	0.09	64%	79%	NS
Emergent procedure	0%	0%	NS	8 (8%)	0 (0%)	0.007	10 (15%)	0 (0%)	0.01
Urgent procedure	1 (2%)	2 (3%)	NS	55 (58%)	37 (44%)	0.09	36 (54%)	13 (34%)	0.05
Heparin before PTCA	3 (7%)	6 (9%)	NS	79 (83%)	62 (74%)	NS	57 (85%)	28 (74%)	NS
IV NTG before PTCA	0%	0%	NS	32 (34%)	19 (23%)	NS	29 (43%)	8 (21%)	0.02
No. of diseased coronary arteries	1.45 ± 0.63	1.70 ± 0.81	NS	1.73 ± 1.32	1.77 ± 1.79	NS	1.31 ± 0.56	1.65 ± 0.82	0.01
No. of lesions dilated	1.43 ± 0.59	1.49 ± 0.63	NS	1.17 ± 0.50	1.32 ± 0.59	0.07	1.19 ± 0.53	1.35 ± 0.63	NS
Lesion class (AHA/ACC)									
A	11 (26%)	23 (33%)	NS	22 (23%)	10 (12%)	NS	11 (16%)	5 (13%)	NS
B	29 (69%)	45 (65%)		68 (72%)	67 (80%)		54 (81%)	31 (82%)	
C	2 (5%)	1 (1%)		5 (5%)	7 (8%)		2 (3%)	2 (5%)	
Technologies used									
Conventional PTCA	15 (36%)	29 (42%)	NS	51 (54%)	37 (44%)	NS	41 (61%)	25 (66%)	NS
Intracoronary stent	26 (62%)	39 (57%)	NS	43 (45%)	44 (52%)	NS	26 (39%)	13 (34%)	NS
DCA	0	0	NS	0	2 (2%)	NS	0	0	NS
Rotational ablation	1 (2%)	1 (1%)	NS	1 (1%)	2 (2%)	NS	0	0	NS

Data are presented as mean value ± SD or number (%) of patients. AHA/ACC = American Heart Association/American College of Cardiology; DCA = directional coronary atherectomy; IV = intravenous; MI = myocardial infarction; NTG = nitroglycerin; PTCA = percutaneous transluminal coronary angioplasty.

Table 2. Costs, Length of Stay and Complications

	Stable Angina			Unstable Angina			Post-MI		
	Ad Hoc	Staged	p Value	Ad Hoc	Staged	p Value	Ad Hoc	Staged	p Value
All Cases									
Costs	$6,295 ± 2,414	$7,199 ± 2,679	0.08	$9,218 ± 7,557	$ 9,599 ± 4,170	NS	$ 9,470 ± 5,536	$ 9,712 ± 4,599	NS
Range	$3,224–13,167	$2,254–13,212		$ 2,347–66,955	$ 1,494–23,254		$ 4,220–33,224	$ 2,893–18,448	
LOS (days)	2.7 ± 1.6	2.8 ± 2.0	NS	5.7 ± 4.5	7.0 ± 5.8	NS	6.2 ± 5.3	5.9 ± 3.2	NS
Range	1–6	1–10		1–26	2–44		2–36	1–13	
Complications	1 (2.4%)	3 (4.3%)	NS	8 (8.4%)	4 (4.8%)	NS	6 (9.0%)	1 (2.6%)	NS
Conventional PTCA Cases									
Costs	$4,890 ± 2,805	$5,623 ± 1,709	NS	$9,065 ± 9,612	$ 8,312 ± 4,296	NS	$ 9,074 ± 6,490	$ 8,067 ± 3,752	NS
LOS	1.8 ± 1.3	2.2 ± 1.5	NS	6.6 ± 5.5	6.5 ± 3.4	NS	6.3 ± 6.2	5.2 ± 3.0	NS
Stent Cases									
Costs	$7,124 ± 1,801	$8,462 ± 2,613	0.03	$9,206 ± 4,120	$10,875 ± 3,796	< 0.05	$10,094 ± 3,586	$12,876 ± 4,535	< 0.05
LOS	3.3 ± 1.5	3.3 ± 2.2	NS	4.2 ± 1.7	7.6 ± 7.3	0.04	6.1 ± 3.1	7.2 ± 3.3	NS

Data presented are mean value ± SD, range or number (%) of patients. LOS = length of hospital stay; other abbreviations as in Table 1.

categories, underwent PTCA in an emergency setting, whereas, by definition, none of the staged procedures were done on an emergency basis. Furthermore, for post-MI patients, more of the patients in the ad hoc group were receiving antecedent nitroglycerin. In contrast, post-MI patients who had a staged procedure tended to have more extensive coronary disease. The trend toward treating more lesions per patient in patients with unstable angina who had a staged procedure was of borderline significance. The use of various interventional technologies is detailed in Table 1 and did not differ between the ad hoc and staged PTCA groups.

The overall outcomes are shown in Table 2. The LOS did not differ between the ad hoc and staged groups in any of the clinical strata. There was a cost savings of borderline significance with an ad hoc strategy in patients with stable angina. Patients with unstable angina or post-MI patients who were treated in an ad hoc fashion tended to incur a greater frequency of complications, although this trend was not statistically significant. The power of our study to detect a significant increase in complications was limited, however. The chance of a beta error was >0.5 to fail to detect as significant (at $p < 0.05$) a difference in complications between ad hoc and staged strategies of 7.4% and 4.2%, respectively (the actual rates in the current study). Complications were an important driver of costs. Patients with complications had significantly higher costs than patients without complications. For patients with stable angina, the occurrence of a complication added, on average, $2,853 to the cost of care ($p = 0.03$). For unstable angina and post-MI, the excess marginal costs for complications were $10,810 ($p < 0.0001$) and $1,993 (p = NS), respectively. We also performed power calculations to determine the amount of cost savings that would have been necessary to achieve a beta error of <0.2 and to detect as significant ($p < 0.05$) a cost difference between the two strategies, given the sample size in the present study. For patients with stable angina, the savings would have to have been >$1,300, for unstable angina >$2,100 and for post-MI >$2,500. Our study, therefore, lacked power to detect smaller cost advantages as significant.

The analyses based on whether patients underwent conventional PTCA alone or received stents are summarized in Table 2. For conventional PTCA, there were no significant differences between staged or ad hoc strategies for any of the comparisons. There were trends, however, toward lower costs with an ad hoc strategy in patients with stable angina and toward lower costs with a staged strategy for patients with unstable angina or for post-MI patients. For patients who received stents, in all cases an ad hoc strategy had significantly lower overall costs as compared with the staged strategy.

The rates of ad hoc procedures were not significantly different among our eight operators and ranged from 43% to 67% of cases. Multivariate analysis identified one variable significantly negatively correlated with costs (stable angina as indication for PTCA) and five variables significantly correlated with increasing costs (MI and shock as indications, number of lesions dilated, age and diabetes mellitus). Whether PTCA was performed staged or ad hoc was not a significant independent variable. When using these variables to adjust the case mix, there was no overall difference between the two strategies (ad hoc $4,736 ± 7,580 vs. staged $4,692 ± 3,734, p = NS). The differences between ad hoc and staged strategies for the three clinical strata were also not significantly different. For stable angina, the difference was $764 in favor of an ad hoc approach ($p = 0.14$); for unstable angina the difference was $83 in favor of an ad hoc approach (p = NS); and for post-MI the difference was $162 in favor of a staged approach (p = NS).

Discussion

Our study demonstrated that an ad hoc strategy of PTCA does not consistently lead to an economic advantage over a

staged strategy. In some clinical settings, ad hoc PTCA was associated with lower costs, whereas in others it was not. Furthermore, the cost advantage, when it occurred, was modest.

In recent years, ad hoc PTCA has become increasingly common, as operators have overcome concerns regarding patient safety and preparedness, surgical backup and potential errors from interventions, based on digital images in the catheterization laboratory (8). In the present study, the trend toward greater complications with ad hoc PTCA strategies in patients with unstable angina, post-MI patients or in the entire cohort did not reach statistical significance, although our study was underpowered to detect this difference. Two similar-sized studies also identified nonsignificant trends toward increased rates of MI or coronary artery bypass graft surgery (CABG) complicating ad hoc PTCA, and the investigators concluded that an ad hoc strategy did not pose any increased risk (1,2). Kimmel et al. (5), however, examined a much larger number of patients and reported significantly greater rates of MI, CABG or death with an ad hoc approach. The economic importance of even a modest trend toward increased complications is greatly magnified by excessive costs. The high costs of even a few complications can quickly negate the cost advantage of shortening the LOS with an ad hoc strategy.

In contrast to our study, O'Keefe et al. (4) reported a significant cost savings with ad hoc PTCA. Their estimate of cost, however, was derived from hospital charges, not direct cost accounting. This methodology has substantial shortcomings (9,10). Furthermore, their study was undertaken before the availability of intracoronary stents and other second-generation interventional devices, which are major contributors to the cost of interventional procedures (11–13).

One variable that may contribute to the lack of consistent clinical and economic advantage of ad hoc PTCA is that of operator selection. Low volume operators with reduced access to catheterization laboratory time may feel the greatest compunction to perform ad hoc PTCA, lest they lose the opportunity to perform the procedure. Furthermore, these same operators may be selecting the most marginal cases if they feel pressured to maintain their volume. It is not likely that such a selection bias played a major role in our study. Although the eight operators in our center varied in the number of years' experience in performing PTCA, they were a very homogeneous group in terms of overall annual volume and complication rates. Furthermore, there were no significant differences in the rates of ad hoc PTCA among our operators, thus making it unlikely that the idiosyncratic practice patterns of any one individual impacted substantially on the overall result.

The cost advantage of an ad hoc strategy was realized in settings where safety appears to be enhanced. Thus, our patients with stable angina, an intrinsically low risk group, had a trend toward lower complications and lower costs with an ad hoc strategy. Furthermore, in all of our clinical strata, patients with stents had lower costs with an ad hoc strategy. Because stenting is effective in addressing dissections and has been associated with falling complication rates (14), it may be safe and cost-saving to perform ad hoc PTCA in patients with coronary lesions of a morphology and caliber suitable for stenting. It would be of interest to examine whether the size of the coronary arteries differed among our ad hoc and staged PTCA and stent groups, but we did not collect this data prospectively. Similarly, the use of glycoprotein IIb-IIIa blockers has been shown to reduce the risks of PTCA-related complications in an economically viable manner (15). Abciximab was available during the course of this study and was used at the discretion of the individual operator. We did not systematically track pharmacologic agents used in the catheterization laboratory and cannot conclude whether abciximab can contribute to a safe or cost-effective ad hoc strategy.

Our study also suggests that the LOS advantages of an ad hoc strategy may not be realized in some clinical settings. Our post-MI patients, for example, did not have lower costs or a shortened LOS. If the overall LOS is being driven by the fact that the patient sustained an MI, then completing the PTCA a day earlier in the hospital period may not translate into any savings. Although it was proposed nearly 10 years ago that early PTCA may promote early discharge of patients with MI (16), a recent large registry report failed to document any shortened LOS with PTCA (17).

Conclusions. An ad hoc strategy of PTCA does not achieve cost savings uniformly in all clinical settings. Even a small increment in complications will negate the cost savings of a shortened LOS. Furthermore, the cost advantages, when realized, were rather modest. The cost advantage of an ad hoc strategy was most likely to be realized in settings associated with enhanced safety.

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